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Fractional and hidden magnetic excitations in f-electron metal Yb2Pt2Pb[1]

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Quantum states with fractionalized excitations such as spinons in one-dimensional chains are commonly viewed as belonging to the domain of S=1/2 spin systems. However, recent experiments on the quantum antiferromagnet Yb2Pt2Pb, part of a large family of R2T2X (R=rare earth, T=transition metal, X=main group) materials spectacularly disqualify this opinion [1,2,3]. The results show that spinons can also emerge in an f-electron system with strong spin-orbit coupling, where magnetism is mainly associated with large and anisotropic orbital moment. Here, the competition of several high-energy interactions Coulomb repulsion, spin-orbit coupling, crystal field, and the peculiar crystal structure, which combines low dimensionality and geometrical frustration, lead to the emergence, at low energy, of an effective spin-1/2, purely quantum Hamiltonian. Consequently, it produces unusual spin-liquid states and fractional excitations enabled by the inherently quantum mechanical nature of the moments [1,2]. The emergent quantum spins bear the unique birthmark of their unusual origin in that they only lead to measurable longitudinal magnetic fluctuations, while the transverse excitations such as spin waves remain invisible to scattering experiments. Similarly hidden would be transverse magnetic ordering, although it would have visible excitations. The rich magnetic phase diagram of Yb2Pt2Pb is suggestive of the existence of hidden-order phases [1,2], while the recent experiments indeed reveal the dark magnon, a hidden excitation in the saturated ferromagnetic (FM) phase of Yb2Pt2Pb [2,3]. Unlike copper-based spin-1/2 chains, where the magnon in the FM state accounts for the full spectral weight of the zero-field spinon continuum, in the spin-orbital chains in Yb2Pt2Pb it is 100 times, or more weaker. It thus presents an example of dark magnon matter, whose Hamiltonian is that of the effective spin-1/2 chain, but whose coupling to magnetic field, the physical probe at our disposal, is vanishingly small. References [1] W. Miiller, L.S. Wu, M. S. Kim, T. Orvis, J. W. Simonson, M. Gamaza, D. E. McNally, C. S. Nelson, G. Ehlers, A. Podlesnyak, J.S. Helton, Y. Zhao, Y. Qiu, J. R. D. Copley, J. W. Lynn, I. A. Zaliznyak, M. C. Aronson. Phys. Rev. B 93, 104419 (2016). [2] L.S. Wu, W. J. Gannon, I. A. Zaliznyak, A. M. Tsvelik, M. Brockmann, J.-S. Caux, M. S. Kim, Y. Qiu, J. R. D. Copley, G. Ehlers, A. Podlesnyak, M. C. Aronson. Science, 352, 1206 (2016). [3] I. A. Zaliznyak, L.S. Wu, A. T. Savici, G. Ehlers, W. J. Gannon, M. Aronson, unpublished (2016).

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